Exploration Medical Capability (ExMC) Science and Research: Overview and Update

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"Expanding the Boundaries of Space Medicine and Technology"

Our Mission

Advance medical system design and risk-informed decision-making for exploration beyond low Earth orbit to promote human health and performance in space

ExMC Risks

Risk of Adverse Health Outcomes & Decrements in Performance due to Medical Conditions that occur In Mission

DRM Categories	Mission Type and Duration	Operations		Long-Term Health	
		LxC	Risk Disposition *	LxC	Risk Disposition *
Low Earth Orbit	Short (<30 days)	3x2	Accepted	3x2	Accepted
	Long (30 days-1 year)	4x2	Accepted	4x2	Accepted
Lunar Orbital	Short (<30 days)	4x2	Accepted	3x2	Accepted
	Long (30 days-1 year)	5x3	Requires Mitigation	4x2	Requires Characterization
Lunar Orbital + Surface	Short (<30 days)	4x3	Requires Characterization	4x2	Requires Characterization
	Long (30 days-1 year)	5x4	Requires Mitigation	4x4	Requires Characterization
Mars	Preparatory (<1 year)	5x4	Requires Mitigation	4x4	Requires Characterization
	Mars Planetary (730-1224 days)	5x5	Requires Mitigation	5x4	Requires Characterization

Risk of Ineffective or Toxic Medications During Long-Duration Exploration Spaceflight

DRM Categories	Mission Type and Duration	Operations		Long-Term Health	
		LxC	Risk Disposition *	LxC	Risk Disposition *
Low Earth Orbit	Short (<30 days)	1x1	Accepted	1x1	Accepted
	Long (30 days-1 year)	1x1	Accepted	1x1	Accepted
Lunar Orbital	Short (<30 days)	1x1	Accepted	1x1	Accepted
	Long (30 days-1 year)	1x1	Accepted	1x1	Accepted
Lunar Orbital + Surface	Short (<30 days)	1x1	Accepted	1x1	Accepted
	Long (30 days-1 year)	1x1	Accepted	1x1	Accepted
Mars	Preparatory (<1 year)	2x2	Accepted	1x1	Accepted
	Mars Planetary (730-1224 days)	3x4	Requires Mitigation	3x4	Requires Mitigation

Human Research Roadmap

ExMC Risks

Risk of Adverse Health and Performance Effects of Celestial Dust Exposure

DRM Categories	Mission Type and Duration	Operations		Long-Term Health	
		LxC	Risk Disposition *	LxC	Risk Disposition *
Low Earth Orbit	Short (<30 days)	*Not Applicable*	*Not Applicable*	*Not Applicable*	*Not Applicable*
	Long (30 days-1 year)	*Not Applicable*	*Not Applicable*	*Not Applicable*	*Not Applicable*
Lunar Orbital	Short (<30 days)	1x2	Accepted	1x2	Accepted
	Long (30 days-1 year)	1x2	Accepted	1x2	Accepted
Lunar Orbital + Surface	Short (<30 days)	1x2	Accepted	1x2	Accepted
	Long (30 days-1 year)	1x3	Requires Mitigation	1x4	Requires Mitigation
Mars	Preparatory (<1 year)	*Not Applicable*	*Not Applicable*	*Not Applicable*	*Not Applicable*
	Mars Planetary (730-1224 days)	To Be Determined	To Be Determined	To Be Determined	To Be Determined

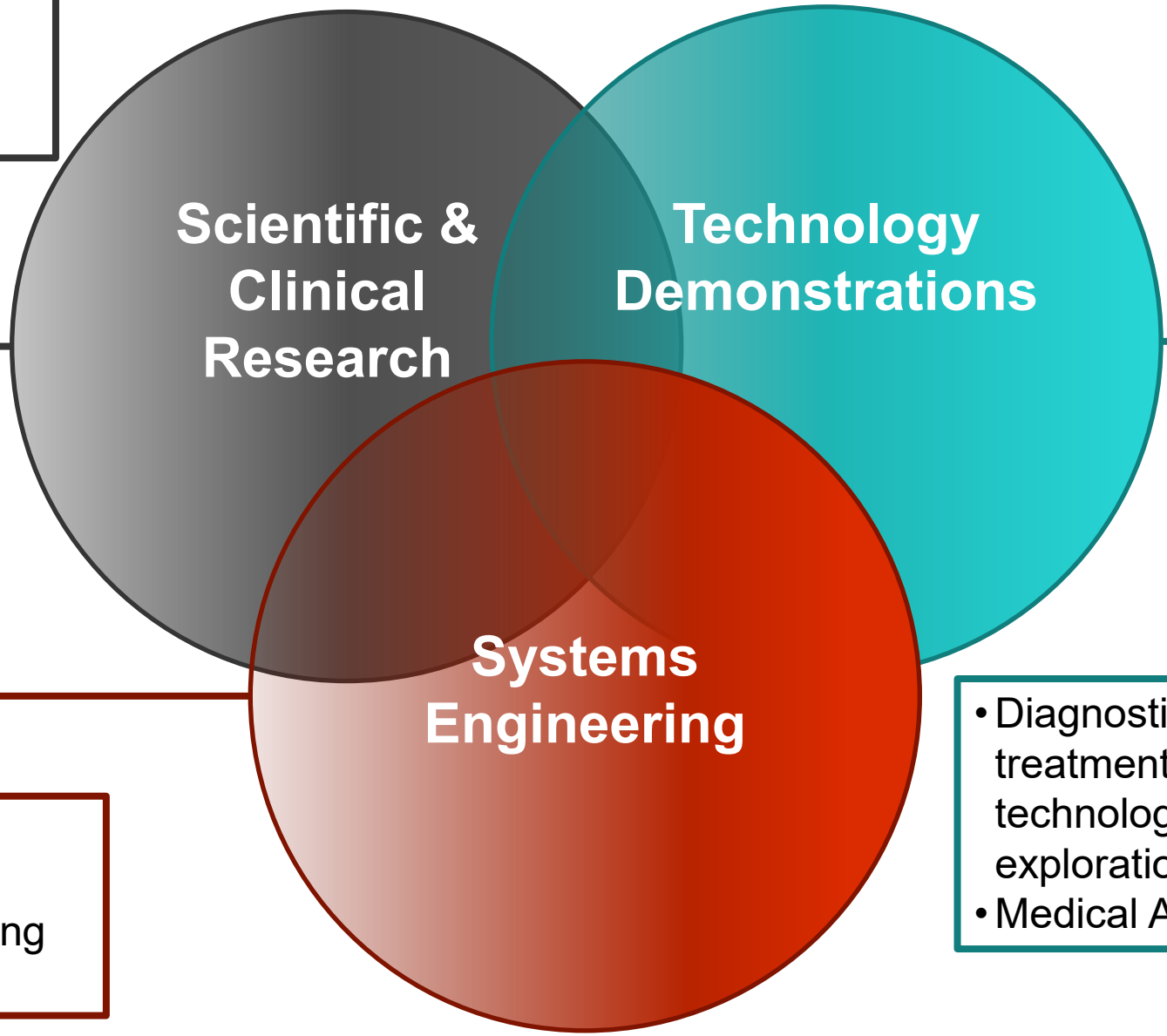
Risk of Renal Stone Formation

DRM Categories	Mission Type and Duration	Operations		Long-Term Health	
		LxC	Risk Disposition *	LxC	Risk Disposition *
Low Earth Orbit	Short (<30 days)	1x4	Accepted with Monitoring	1x3	Accepted with Monitoring
	Long (30 days-1 year)	3x4	Accepted with Monitoring	2x3	Accepted with Monitoring
Lunar Orbital	Short (<30 days)	1x4	Accepted with Monitoring	1x3	Accepted with Monitoring
	Long (30 days-1 year)	3x4	Accepted with Monitoring	2x3	Accepted with Monitoring
Lunar Orbital + Surface	Short (<30 days)	1x4	Accepted with Monitoring	1x3	Accepted with Monitoring
	Long (30 days-1 year)	3x4	Accepted with Monitoring	2x3	Accepted with Monitoring
Mars	Preparatory (<1 year)	3x4	Requires Mitigation	3x4	Requires Mitigation
	Mars Planetary (730-1224 days)	4x4	Requires Mitigation	4x4	Requires Mitigation

Human Research Roadmap

Focus Areas

- Clinical research (e.g., pharm)
- Scientific publications
- Clinical evidence for trade space tools



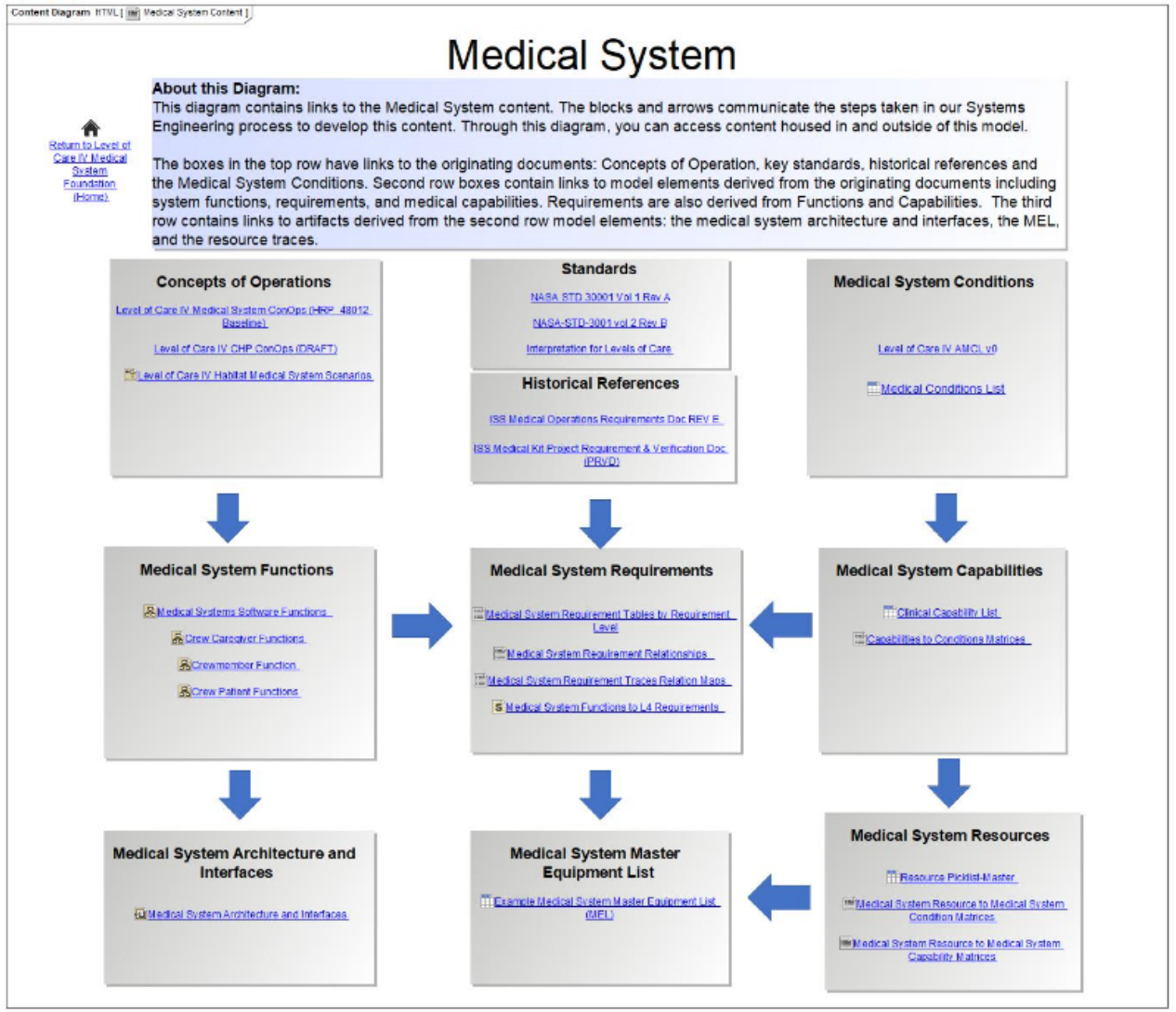
- Concepts of Operations
- Requirements development
- Model-based Systems Engineering
- Trade space analysis

- Diagnostic and treatment technologies for exploration missions
- Medical Autonomy

ACCOMPLISHMENTS – 2021

CURRENT AND FUTURE EFFORTS – 2022 AND BEYOND

Accomplishments
Short Duration Lunar Medical System Foundation



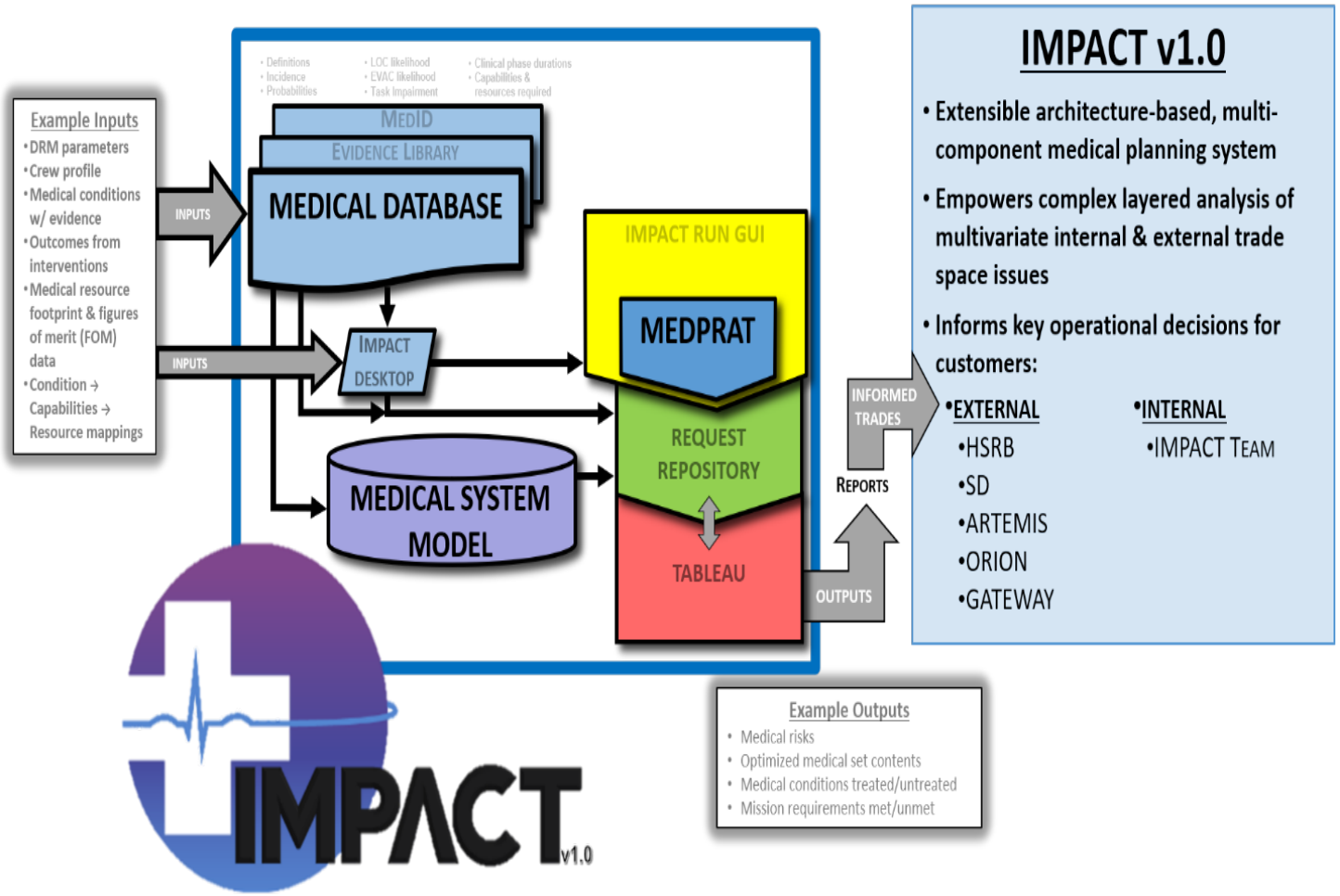
- Developed a Medical System Foundation for Short Duration Lunar Orbital Missions (42-day Gateway)
  - Concept of Operations
  - Accepted Medical Condition List
  - System Model with Requirements and traces
- Publicly available on ExMC website

Future - Long Duration Lunar Medical System Foundation

- Developing a Medical System Foundation for Long Duration (~270 day) Lunar Orbital and Lunar Surface Missions
  - Concept of Operations
  - System Model with Requirements and traces
  - Gateway
  - HLS
  - Surface EVAs

Accomplishments – IMPACT Medical Database

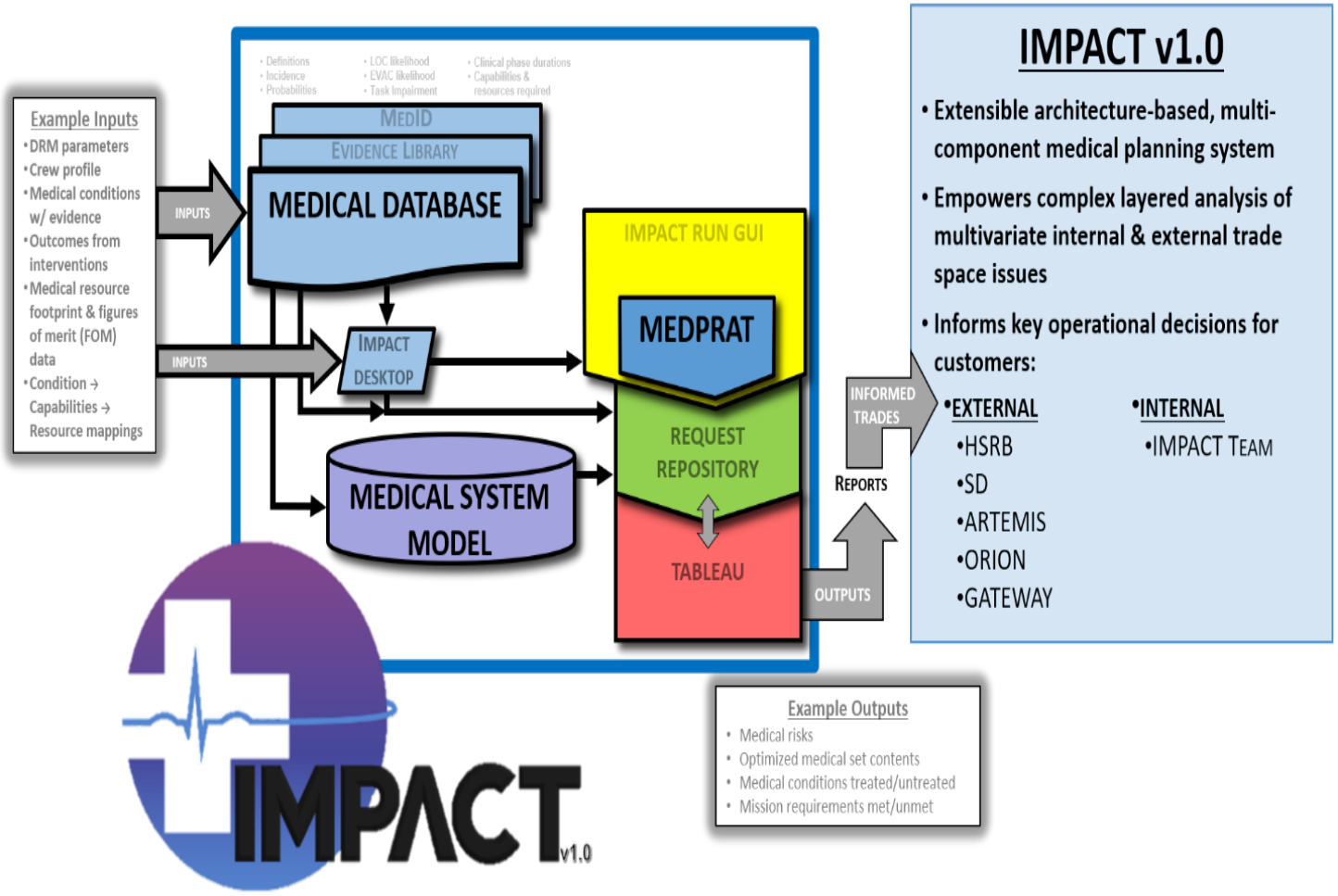
IMPACT = Informing Mission Planning via Analysis of Complex Tradespaces



- **Evidence Library**
  - 120 medical conditions baselined to lunar missions
  - Incidence, Best Case/Worst case definitions, Durations
  - Effect on Loss of Crew Life, Return to Definitive Care, Task Impairment
- **Medical Item Database**
  - Populated Figures of Merit for 418 clinical resources and 268 pharmaceutical resources
  - 41,485 data field on medical items

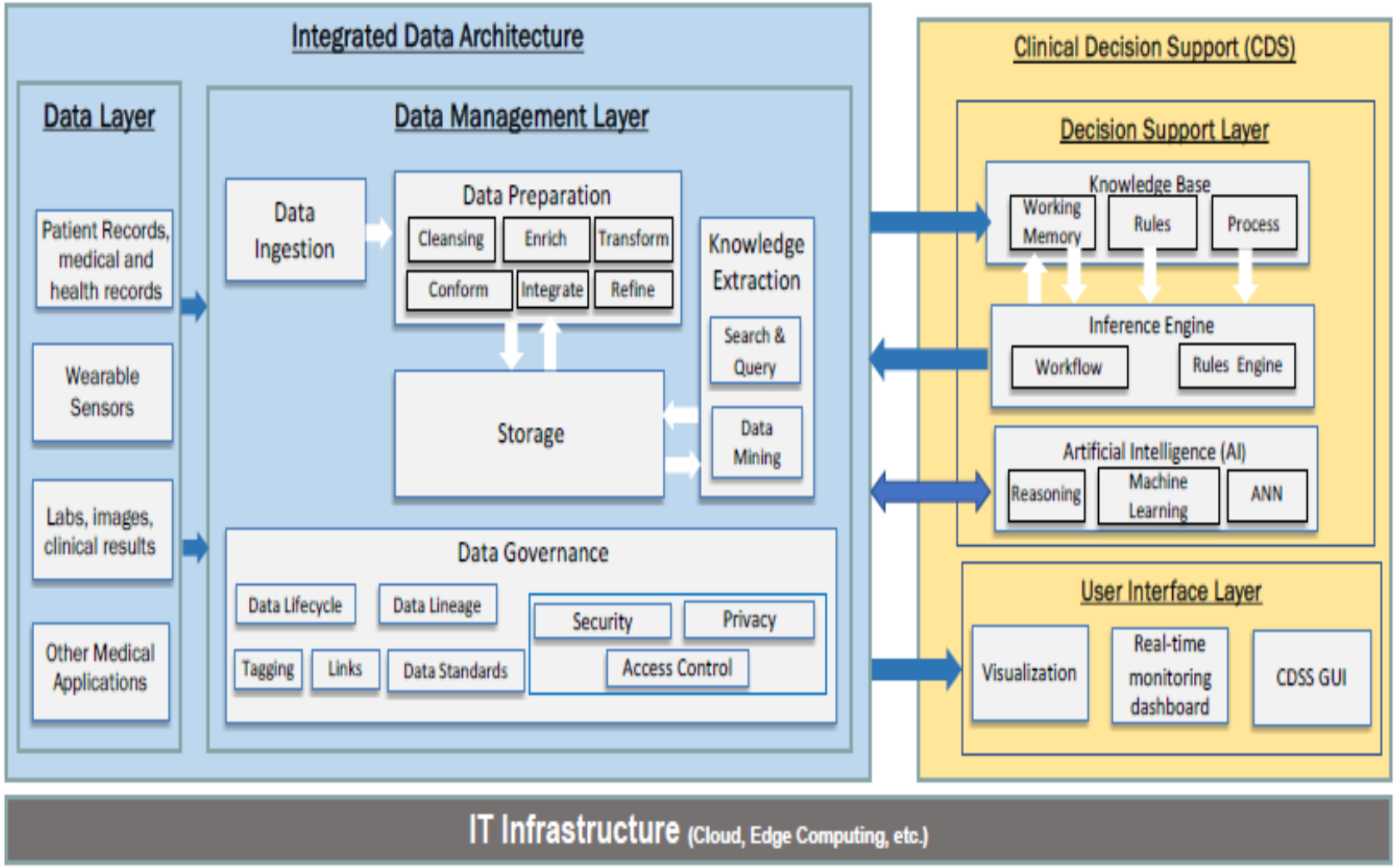
Future – IMPACT v1.0

IMPACT = Informing Mission Planning via Analysis of Complex Tradespaces



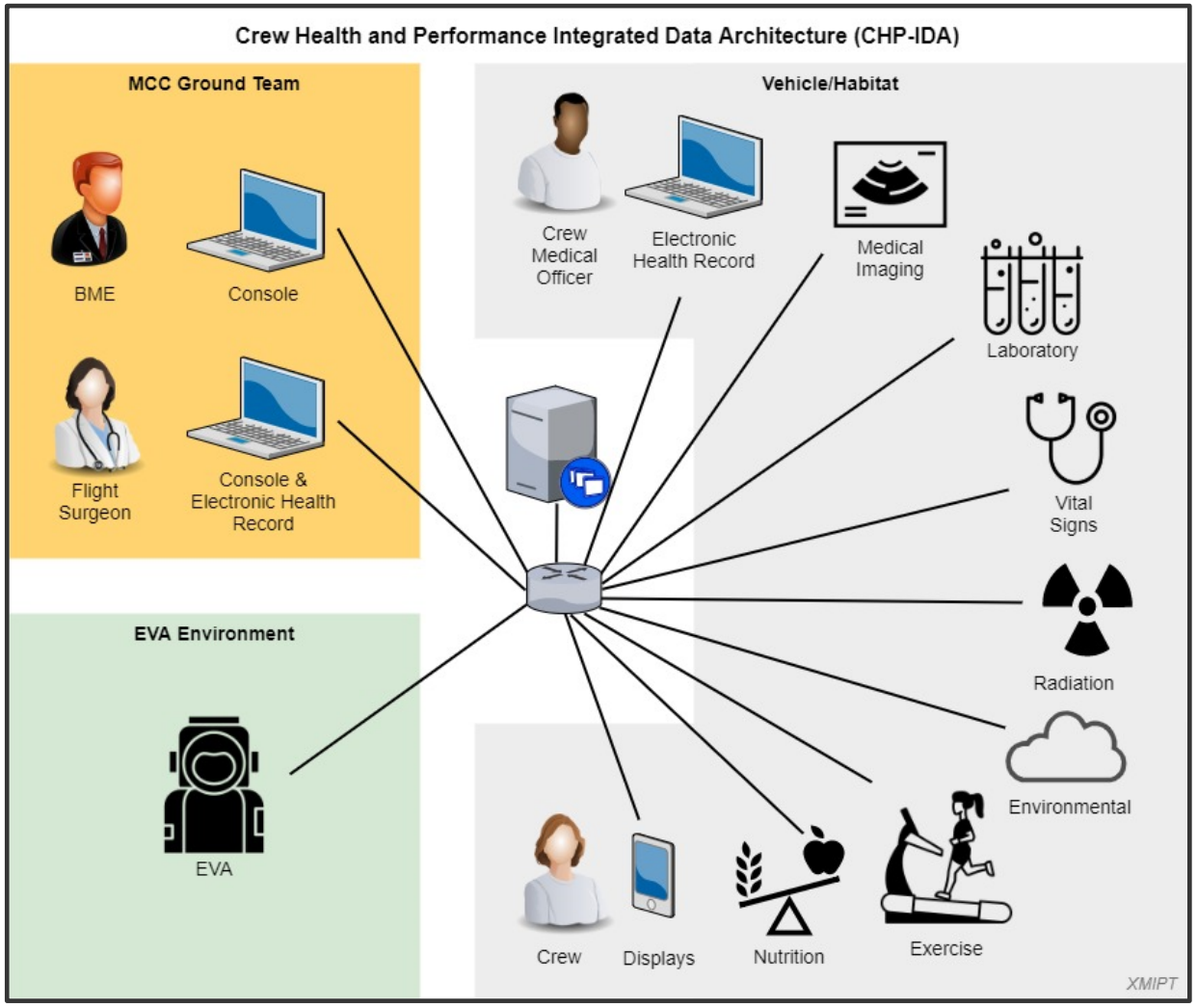
- Delivery end of FY22
- Operational tool within NASA FY23 (to replace IMM)
- Considering options to make IMPACT (results) available external to NASA
- Much more detail in additional IMPACT presentations…

Accomplishments – Clinical Decision Support



- Clinical Decision Support System (CDSS) enables crew autonomy for medical decisions/procedures
- Development
  1. Concept of Operations
  2. Architecture Recommendation
  3. Functional Requirements for Level of Care IV (Moon) and Level of Care V (Mars)

Future - Crew Health and Performance Integrated Data Architecture



- Integrate data across multiple domains that are relevant for human health and performance
- Provide new insights into data
- Present data in a manner that allows crew to take make decisions and take action (progressive Earth independence)

Accomplishments – Tech Demos

Autonomous Medical Officer Support (AMOS)

- AMOS used to perform ultrasound of the bladder and kidneys in **autonomous fashion with no preflight training and no support from the ground**
- **1st spaceflight performance** of fully autonomous, untrained imaging
- Awarded the International Space Station Research and Development **2020 Compelling Results Award- Human Health**

Hemocue ®

- Device for **point-of-care** analysis of white blood cell count and differential
- Validated performance in flight using control solutions and a fingerstick blood sample
- **1st real-time hematology performed in space**

Contents lists available at ScienceDirect

Life Sciences in Space Research

journal homepage: www.elsevier.com/locate/lssr

Spaceflight validation of technology for point-of-care monitoring of peripheral blood WBC and differential in astronauts during space missions

Future Tech Demo - rHEALTH ONE®

- Integrated blood analyzer & vital signs sensors
- ISS technology demonstration using COTS process to validate spaceflight performance
  - rHEALTH ONE® Integrated blood analyzer & vital signs sensor, 2-channel laser flow cytometry of hemoglobin; nano-strips measure other analyte concentrations (next gen = rHEALTH AWESOME®)
  - Tech demonstration planned this year

Selected Future Focus Areas

- **Pharmacology Studies**
  - Stability and shelf-life data from FDA
  - Influence of packaging on medication stability
  - Pharmacokinetics Modeling
- **Earth Independent Medical Operations (EIMO)**
- **Tempus Pro® Tech Demo**


EXMC
EXPLORATION MEDICAL CAPABILITY
NASA
Questions?
"Expanding the Boundaries of Space Medicine and Technology"

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